

What is claimed is:

1. A wafer-level compressive-flow underfilling (WLCFU) process comprising the steps of:

a. applying a WLCFU material onto a surface of a bumped wafer in an amount sufficient to ensure that the thickness of the solidified WLCFU layer is less than the height of the wafer bumps;

b. solidifying the WLCFU material;

c. separating the WLCFU material coated wafer into individual chips;

d. covering the top of the bumps with a tacky film;

e. mounting the WLCFU material and tacky film coated individual chips to substrates; and

f. reflowing the solder bumps and curing the WLCFU material and tacky film simultaneously.

2. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 1, wherein said WLCFU material is a solvent-containing WLCFU material and said solidifying step includes the step of solidifying said WLCFU material by solvent removal.

3. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 1, wherein said WLCFU material is a solvent-free fluxing WLCFU material and said WLCFU solidifying step includes the step of solidifying said WLCFU material by cooling.

4. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 1, further comprising a post-curing step.

5. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 1, wherein said WLCFU material comprises:

a. an epoxy resin;

b. an organic curing hardener;

c. a latent curing catalyst;

d. a fluxing agent; and

e. a silica filler.

6. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said epoxy resin is selected from the group consisting of: a cycloaliphatic epoxy resin, a bisphenol A epoxy resin, a bisphenol F epoxy resin, an epoxy novolac resin, a biphenyl epoxy resin, a naphthalene epoxy resin, a dicyclopentadiene-phenol epoxy resin, a reactive epoxy diluent, and any mixture thereof.

7. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said organic curing hardener is selected from the group consisting of: a phenolic resins, an aromatic amine, a carboxylic acid anhydride, an imidazole, and an imidazole derivative.

5 8. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5 wherein said curing catalyst is selected from the group consisting of: a tertiary amine, a tertiary phosphine, an imidazole, an imidazole derivative, an imidazolium salt, a metal chelate, an onium salts, a quaternary phosphonium compound, 1,8-diazacyclo[5.4.0]undec-7-ene, and any mixture thereof.

10 9. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said fluxing agent comprises a compound containing a hydroxyl (-OH) group.

10. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said fluxing agent comprises a compound containing a carboxylic (-COOH) group.

11. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said silica filler is selected from the group consisting of: a spherical fused silica filler, a silicon nitride filler, a silver flake filler, and a gold flake filler with diameters ranging from 0.1 μ m to 50 μ m.

12. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said WLCFU material further comprises a solvent.

13. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 12, wherein said solvent is an organic chemical having a boiling point between 25°C to 200°C which does not react with any other components in the WLCFU composition/formulation.

14. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 12, wherein said solvent is 4-methyl-2-pentanone.

15. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said WLCFU material further comprises an adhesion promoter.

16. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 15, wherein said adhesion promoter is selected from the group consisting of: a silane coupling agent, a titanate, and a zirconate.

17. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 5, wherein said WLCFU material further comprises a surfactant.

18. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 17, wherein said surfactant is a non-ionic surfactant.

19. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 1, wherein said tacky film comprises:

- a. an epoxy resin;
- b. an organic curing hardener;
- c. a latent curing catalyst; and
- d. a fluxing agent.

20. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said tacky film is selected from the group consisting of: a cycloaliphatic epoxy resin, a bisphenol A epoxy resin, a bisphenol F epoxy resin, an epoxy novolac resin, a biphenyl epoxy resin, a naphthalene epoxy resin, a dicyclopentadiene-phenol epoxy resin, a reactive epoxy diluent, and any mixture thereof.

21. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said organic curing hardener is selected from the group consisting of a phenolic resin, an aromatic amine, a carboxylic acid anhydride, an imidazole, and an imidazole derivative.

22. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said latent curing catalyst is selected from the group consisting of: a tertiary amine, a tertiary phosphine, an imidazole, an imidazole derivative, an imidazolium salt, a metal chelate, an onium salts, a quaternary phosphonium compounds, 1,8-diazacyclo[5.4.0]undec-7-ene, and any mixture thereof.

23. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said fluxing agent comprises a compound containing a hydroxyl (-OH) group.

24. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said fluxing agent comprises a compound containing a carboxylic (-COOH) group.

25. ~~The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said tack film further comprises and adhesion promoter.~~

26. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 25, wherein said adhesion promoter is selected from the group consisting of: a silane coupling agent, a titanates, and a zirconate.

27. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 19, wherein said tacky film further comprises a surfactant.

28. The wafer-level compressive-flow underfilling (WLCFU) process of Claim 27, wherein said surfactant is a non-ionic surfactant.

29. A wafer-level compressive-flow underfilling (WLCFU) material comprising:

- a. an epoxy resin;
- b. an organic curing hardener;
- c. a latent curing catalyst;
- d. a fluxing agent; and
- e. a silica filler.

30. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said epoxy resin is selected from the group consisting of: a cycloaliphatic epoxy resin, a bisphenol A epoxy resin, a bisphenol F epoxy resin, an epoxy novolac resin, a biphenyl epoxy resin, a naphthalene epoxy resin, a dicyclopentadiene-phenol epoxy resin, a reactive epoxy diluent, and any mixture thereof.

31. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said organic curing hardener is selected from the group consisting of: a phenolic resins, an aromatic amine, a carboxylic acid anhydride, an imidazole, and an imidazole derivative.

32. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29 wherein said curing catalyst is selected from the group consisting of: a tertiary amine, a tertiary phosphine, an imidazole, an imidazole derivative, an imidazolium salt, a metal chelate, an onium salts, a quaternary phosphonium compound, 1,8-diazacyclo[5.4.0]undec-7-ene, and any mixture thereof.

33. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said fluxing agent comprises a compound containing a hydroxyl (-OH) group.

34. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said fluxing agent comprises a compound containing a carboxylic (-COOH) group.

35. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said silica filler is selected from the group consisting of: a spherical fused silica filler, a silicon nitride filler, a silver flake filler, and a gold flake filler with diameters ranging from 0.1 μ m to 50 μ m.

36. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said WLCFU material further comprises a solvent.

37. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said solvent is an organic chemical having a boiling point between 25°C to 200°C which does not react with any other components in the WLCFU composition/formulation.

38. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said solvent is 4-methyl-2-pentanone.

39. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said WLCFU material further comprises an adhesion promoter.

40. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said adhesion promoter is selected from the group consisting of: a silane coupling agent, a titanate, and a zirconate.

41. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said WLCFU material further comprises a surfactant.

42. The wafer-level compressive-flow underfilling (WLCFU) material of Claim 29, wherein said surfactant is a non-ionic surfactant.

43. A tacky film material for use in a wafer-level compressive-flow underfilling (WLCFU) process, said tacky film material comprising:

- a. an epoxy resin;
- b. an organic curing hardener;
- c. a latent curing catalyst; and
- d. a fluxing agent.

44. The tacky film material of Claim 43, wherein said epoxy resin is selected from the group consisting of: a cycloaliphatic epoxy resin, a bisphenol A epoxy resin, a bisphenol F epoxy resin, an epoxy novolac resin, a biphenyl epoxy resin, a naphthalene epoxy resin, a dicyclopentadiene-phenol epoxy resin, a reactive epoxy diluent, and any mixture thereof.

45. The tacky film material of Claim 43, wherein said organic curing hardener is selected from the group consisting of a phenolic resin, an aromatic amine, a carboxylic acid anhydride, an imidazole, and an imidazole derivative.

46. The tacky film material of Claim 43, wherein said latent curing catalyst is selected from the group consisting of: a tertiary amine, a tertiary phosphine, an imidazole, an imidazole derivative, an imidazolium salt, a metal chelate, an onium salts, a quaternary phosphonium compounds, 1,8-diazacyclo[5.4.0]undec-7-ene, and any mixture thereof.

47. The tacky film material of Claim 43, wherein said fluxing agent comprises a compound containing a hydroxyl (-OH) group.

48. The tacky film material of Claim 43, wherein said fluxing agent comprises a compound containing a carboxylic (-COOH) group.

49. The tacky film material of Claim 43, further comprising an adhesion promoter.

5 50. The tacky film material of Claim 49, wherein said adhesion promoter is selected from the group consisting of: a silane coupling agent, a titanates, and a zirconate.

51. The tacky film material of Claim 43, further comprising a surfactant.

52. The tacky film material of Claim 51, wherein said surfactant is a non-ionic surfactant.

10 53. The tacky film material of Claim 43, further comprising a silica filler.

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